Electromagnetic Interference to 5.2-GHz-band Wireless LANs

Yoshiharu Hiroshima†*, Yoshiharu Akiyama, and Hiroshi Yamane*

Abstract

Although the electromagnetic environment and interference characteristics for 2.4-GHz-band wireless local area networks (LANs) have been studied, those for 5.2-GHz-band ones have not. This paper presents measurements for the electromagnetic environment in a city and describes the characteristics of interference from microwave medical treatment machines to 5.2-GHz-band wireless LANs, which should be taken into consideration.

1. Introduction

The rapid development of telecommunications systems, especially wireless communications systems, has made it easy to introduce information technology (IT) into homes and access it in offices and cities. Examples of wireless communications systems that have spread widely now include some using the 2.4-GHz ISM (industrial, science, and medical) band. This band can be used in Japan without a radio license if proof of conformity to technical standards is provided. Therefore, since wireless systems and ISM equipment are used, interference in this band is an unavoidable problem. Consequently, the 5.2-GHz band, which has few sources of interference, is attracting attention, and regulations for outdoor use are also advanced.

Although the electromagnetic environment and the interference characteristics for the 2.4-GHz-band have been studied [1], [2], those for 5.2-GHz-band wireless LANs have not, so research on the electromagnetic environment and interference characteristics is needed to establish methods for designing base stations of such wireless systems when they are set in a city area.

We investigated the following to understand the actual electromagnetic compatibility (EMC) problems of 5.2-GHz-band wireless LANs that are close to an interference source in a city area.

(1) Measurements of the electromagnetic environment of the 5.2-GHz band

We measured the electromagnetic field strength in some city locations. The measurements were repeated at various times of the day.

(2) Research on the characteristics of interference from microwave medical treatment machines to wireless LANs

We built an experimental communication system and noise-injecting system. We used microwave medical treatment machines (MMTMs) as a source of interference in a city area and a commercial 5.2-GHz-band wireless LAN card. The characteristics of communication degradation caused by the interference from the MMTM to the wireless LAN were measured. Several models of wireless LAN equipment and MMTMs were prepared. The communication system and the injecting system consisted of cable paths.

2. Investigation of electromagnetic environment

The electric field strength of the 5.2-GHz band (4.9–5.3 GHz) at some points in the city was measured to understand the electromagnetic environment of 5.2-GHz-band wireless LANs. The measurement

† NTT Energy and Environment Systems Laboratories
Musashino-shi, 180-8585 Japan
E-mail: hiroshima.yoshiharu@lab.ntt.co.jp

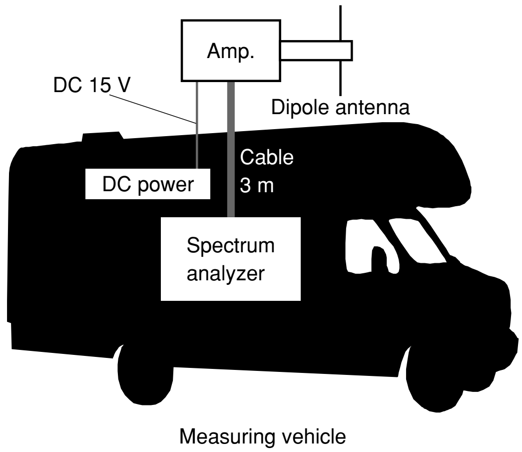

Fig. 1. Setup of measuring electromagnetic environment.

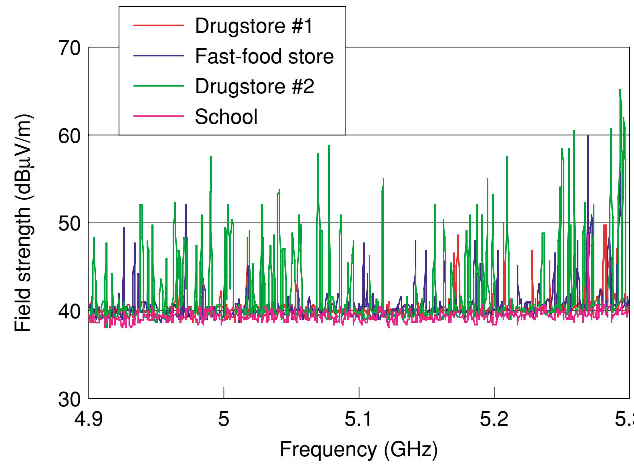

Fig. 2. Outdoor electric field intensity (changes for different places).

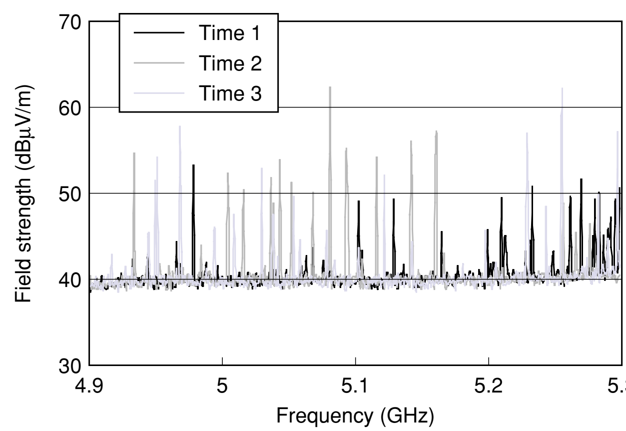

Fig. 3. Outdoor electric field intensity (changes over time).

setup is shown in **Fig. 1**. We used a measuring vehicle with an extendable arm on its roof (3.3 m above the ground) and a dipole antenna and signal amplifier. The signal amplifier was installed as near the antenna as possible considering signal attenuation.

Electromagnetic field measurement was carried out while moving at about 10 km/h using the measuring equipment (spectrum analyzer) installed in the measuring vehicle. The maximum value of received signals for 30 s was taken as data. At places with much noise, the measuring vehicle stopped and measurements that changed over time were repeated at various times to see if the environmental factors changed with time. The measurement parameters were as follows.

- Resolution band width (RBW): 1 MHz,
- Video band width (VBW): 1 MHz.

Examples of measurement results are shown in **Figs. 2** and **3**. Measured places were roads facing drugstores (two places), one fast-food store, and one school as examples of comparatively quiet environments. Figure 2 shows that noise appeared over the whole measured band near the store, while no noise appeared at the school etc. in the comparatively quiet environment. Figure 3 shows the results of measuring every other hour in front of drugstore #2 in Fig. 2. We think that the peaks were observed at random because the noise was wideband and its appearance time and sweep time were asynchronous.

To clarify the cause of the broadband noise measured near the drugstore, we measured the time and frequency characteristics using a realtime spectrum analyzer. In this measurement, we used a horn antenna, which has high directivity, to pinpoint the source of interference.

The measurement results when turning the antenna toward drugstore #2 are shown in **Fig. 4**. Figure 4(a) shows the frequency characteristics of the maximum value of received field strength for 30 s. In Fig. 4(b), the horizontal axis expresses frequency and the vertical axis expresses time. The frequency span is 30 MHz and the time span is 9.25 ms.

Noise covering the whole band was observed once during a period of 9.25 ms and the measured frequency characteristics show that the noise occurred all over the measured band from 4 to 6 GHz. It is possible that the noise was radiated from the drugstore's security system, but this was not confirmed.

3. Characteristics of interference from MMTMs

Equipment that radiates in the 5.2-GHz band other than current wireless LANs is restricted in terms of installation location such as weather radar and is considered to have a low possibility of interfering with wireless LANs. However, ISM equipment that uses the 2.4-GHz band may radiate harmonics near 5.2 GHz, and may cause interference. Therefore, in this study, we measured the characteristics of interference to 5.2-GHz-band wireless LANs. As a source of interference, we chose the MMTM (which is ISM equipment) and observed the radiation near 5.2 GHz. The specifications of the wireless LAN equipment used for measurement and MMTMs as interference sources are given in **Tables 1** and **2**, respectively.

3.1 Communication characteristics of wireless LAN

Before measuring the interference characteristics, we used a spectrum analyzer to measure the signal spectrum of a model-A 5.2-GHz-band wireless LAN that can choose the communication channel. The measurement parameters were as follows.

- RBW: 10 kHz
- VBW: 10 kHz
- Holding time of maximum value: 30 s

Measurement results are shown in **Fig. 5**. The radiation from some MMTMs is also shown. The measured values for both a wireless LAN and MMTM are the receiving port voltage [dBµV] of the measurement equipment. Noise of almost the same level as signals came from MMTMs on some channels.

3.2 Interference with wireless LAN communication

The setup for measuring the interference characteristics is shown in **Fig. 6**. To eliminate multi-path or delay effects, we replaced the radio transmission path

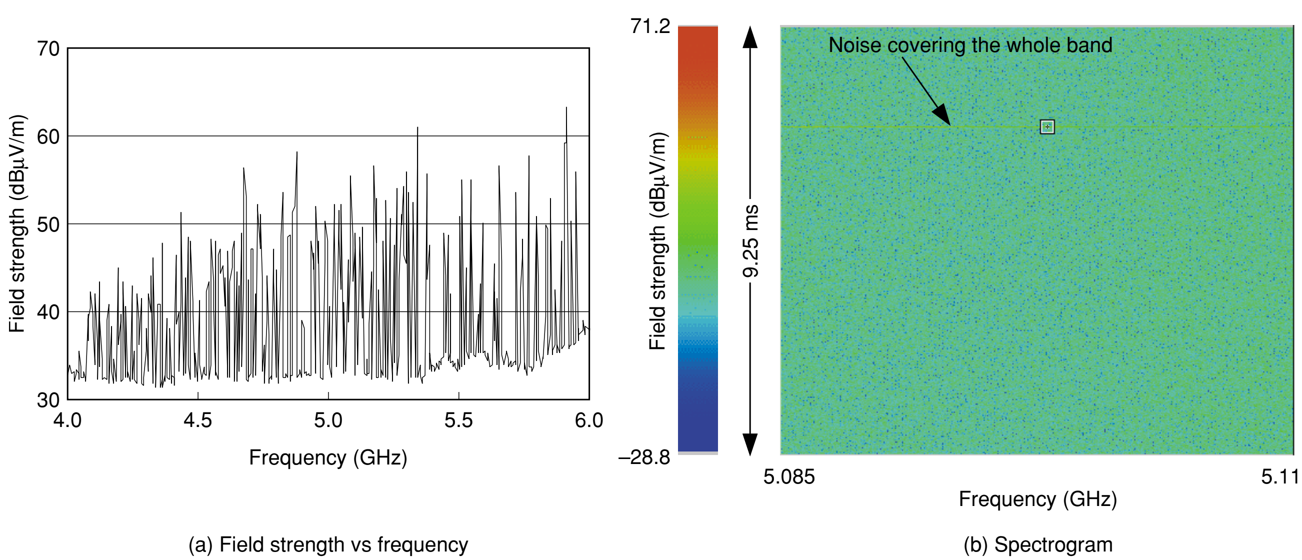

Fig. 4. Electromagnetic field strength measured at drugstore #2.

Table 1. Wireless LAN equipment.

	Model A	Model B
Frequency	5.1–5.2 GHz	5.1–5.2 GHz
Modulation	OFDM	OFDM
Transmission distance	90 m (6 Mbit/s)	100 m
Note	channel tunable	channel tuned automatically

Table 2. MMTMs.

	Model 1	Model 2	Model 3	Model 4
Maker	A	B	B	C
Drive	Transformer type	Transformer type	Transformer type	Inverter type
Max. power	150 W	100 W	100 W × 2 arms	200 W

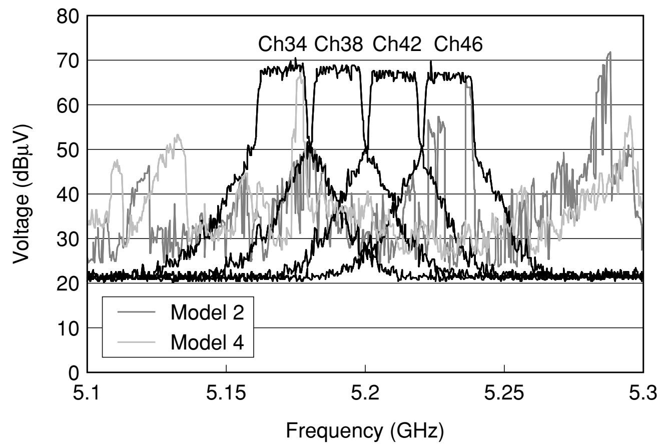

Fig. 5. Signal power of 5.2-GHz-band wireless LAN.

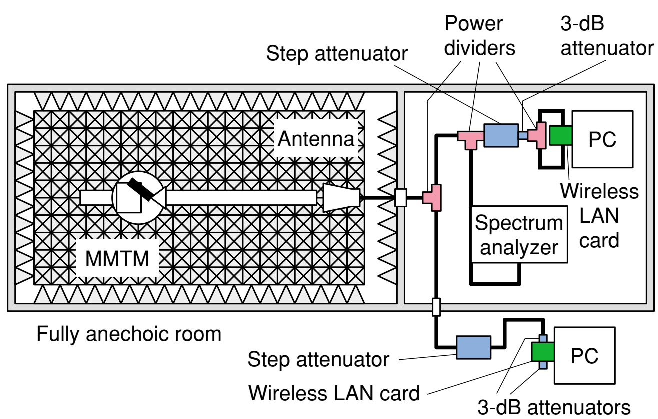

Fig. 6. Setup for measuring interference characteristics.

by a cable transmission path (coaxial cable). In a fully anechoic room (FAR) measurement, the coaxial cable was connected to two antenna ports of a wireless LAN card, and the output was compounded with power dividers. The compounded output was connected to one antenna port of the wireless LAN card outside the FAR through the coaxial cable. The noise from an MMTM was inserted through power dividers.

Throughput was chosen as an evaluation factor, and the average throughput when changing the output of the MMTMs and the wireless LANs by two step attenuators was measured. Commercial software was used for throughput measurement. Measurements were carried out ten times and the average, maximum, and minimum values were recorded. The throughput characteristics without noise were also recorded.

The measured characteristics of interference to the model-A wireless LAN from MMTMs are shown in **Figs. 7** and **8**. Measurements were carried out for channels 34 and 46 for which the noise from MMTMs was obtained by measurement as shown in Fig. 6. The horizontal axis is the sum of the attenuation caused by the two step attenuators.

For the measured value in channels 34 and 46, when the attenuation exceeded 30 dB, throughput decreased rapidly. This tendency was independent of the existence of noise injected from MMTMs. We think that the change in this throughput depended on the attenuation of the transmitted signal and not on the in-band interference from MMTMs. However, only at the time of injection from model 4, throughput degradation was seen when the amount of attenuation was small. This is probably because the amplifier saturated when strong noise was radiated near the

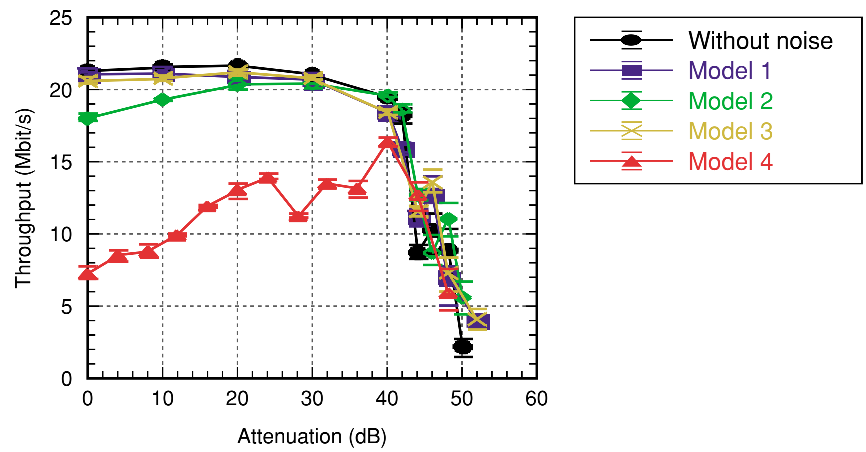

Fig. 7. Interference from MMTM (Model A, Ch34).

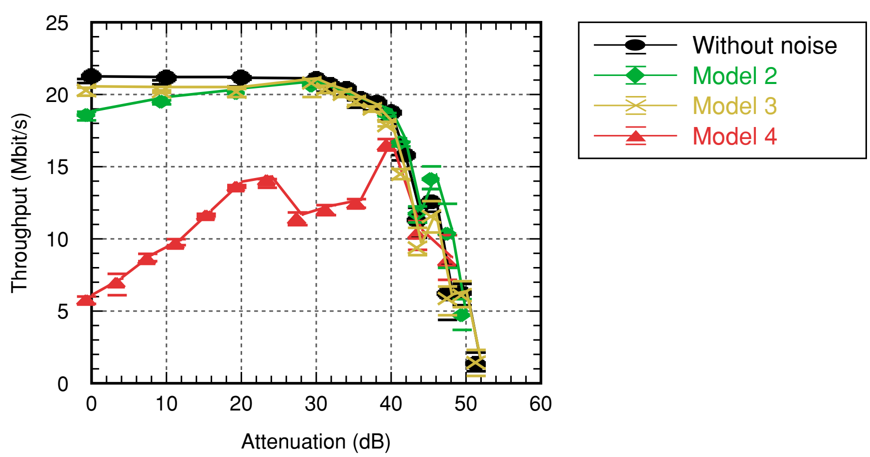

Fig. 8. Interference from MMTM (Model A, Ch46).

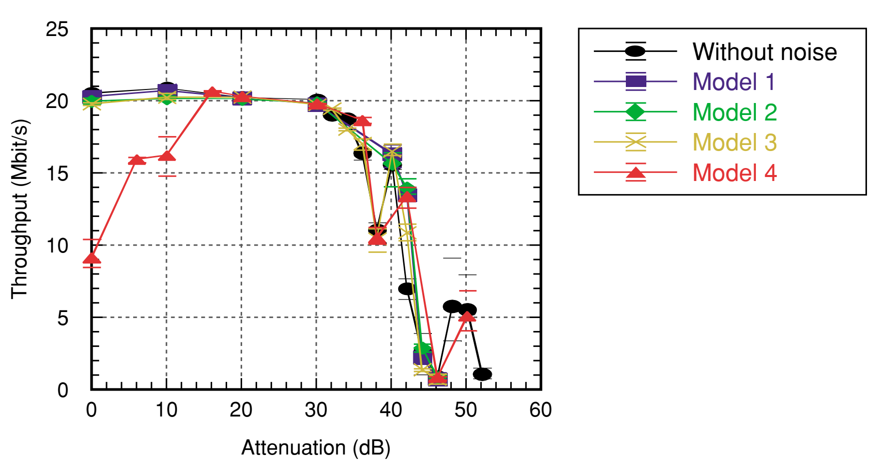

Fig. 9. Interference from MMTM (Model B, Ch34).

band and was received by wireless LAN equipment. If this degradation had been caused by in-band interference from MMTMs, the degradation would have been seen when the attenuation was big.

The measured characteristics for a model-B wireless LAN of interference from MMTMs are shown in **Fig. 9**. Since one communication channel was set up arbitrarily, model-B was measured for the single channel. Like model-A, when the attenuation exceeded 30 dB, throughput decreased rapidly independent of the existence of injection from MMTMs. Moreover, only at the time of injection from model 4, throughput degradation was seen when the attenuation was small, this tendency was also the same. Since the same tendency was seen even though models A and B use different operating systems, this degradation may not originate in the personal computer used for control and may influence wireless LAN equipment.

4. Conclusion

To establish a base station design method for wireless LAN access systems, we investigated the electromagnetic environment of the 5.2-GHz band and the characteristics of interference to 5.2-GHz-band wireless LANs when MMTMs were chosen as sources of interference.

Impulse noise appeared in outdoor environments. Moreover, the maximum electric field strength was estimated to be 60 dBμV/m. For the interference measurement of 5.2-GHz-band wireless LANs from MMTMs, although there was no interference in the band, one model of MMTM showed that throughput degradation might be caused by noise near the band.

In this paper, we considered only the relative level difference between noise and signal. Since the access speed is set up according to the state of the transmission path in a 5.2-GHz-band wireless LAN, in order to perform interference measurement in each transmission state, it is necessary to change the signal and noise levels independently.

References

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Yoshiharu Hiroshima
Research Engineer, Energy Systems Project, NTT Energy and Environment Systems Laboratories.
He received the B.E. and M.E. degrees in electrical and communication engineering from Tohoku University, Sendai, Miyagi in 1986 and 1988, respectively. In 1988, he joined NTT Electrical Communication Laboratories, Musashino. He has been researching EMC measurement for telecommunication systems. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE).

Yoshiharu Akiyama
Senior Manager, Energy Systems Project, NTT Energy and Environment Systems Laboratories.
He received the B.E. degree in electronic engineering from the University of Electro-Communications, Chofu, Tokyo in 1990. In 1990, he joined NTT Electrical Communication Laboratories, Musashino. He has been researching EMC on wireless communications and home networking system. He is a member of IEICE.

Hiroshi Yamane
Senior Research Engineer, Supervisor, Energy Systems Project, NTT Energy and Environment Systems Laboratories.
He received the B.E., M.E., and D.E. degrees in electronic engineering from Ibaraki University, Hitachi, Ibaraki in 1980, 1982, and 1997, respectively. In 1982, he joined the Electrical Communication Laboratories, Nippon Telegraph and Telephone Public Corporation (now NTT), Ibaraki. He has been researching lightning surge and overvoltage protection for telecommunications systems. He is a member of IEICE.